Update of MICE RF Cavities and CC Magnets

30th MICE Collaboration Meeting

Oxford University, UK

July 6, 2011

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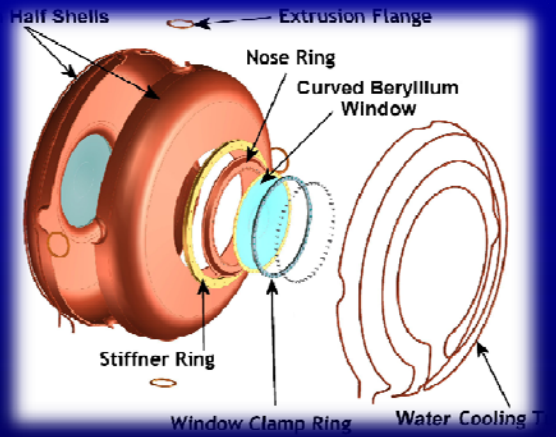
Outline

- **Overview of MICE RFCC module**
  - RF cavities and superconducting coupling coil magnets
- **Current status of the RFCC module**
  - RF cavity (A. DeMello)
  - CC magnets
- **Plan and schedule**
  - Tasks/schedule
- **Summary**

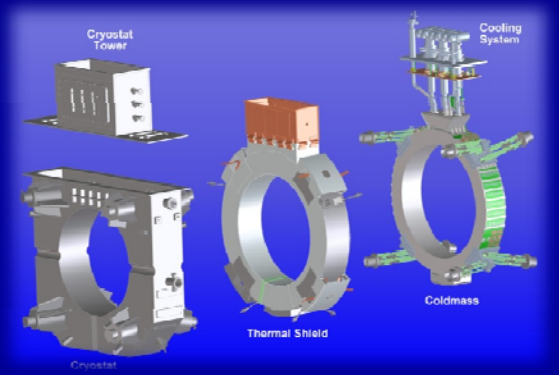
The RFCC Module: RF Cavities

- **Four normal conducting 201-MHz RF cavities mounted in a vacuum vessel**
  - Cavity is formed by e-beam welding from two spun half shells;
  - Large beam iris (21-cm radius) terminated by thin and curved beryllium windows (no differential pressure on the windows);
  - Four ports on each cavity: two coaxial loop couplers with integrated ceramic windows; one vacuum port; one view and diagnostic port;
  - Six evenly spaced tuners on cavity equator;
  - Water cooling pipes brazed to cavity body;
  - EP of the cavity inner surface;
  - Support structure and vacuum vessel.
- **See Allan DeMello's presentation**



The RFCC Module: SC CC Magnet

- **Design and fabrication in collaboration with Harbin Institute of Technology (HIT) and Shanghai Institute of Applied Physics (SINAP), fabrication contract awarded to Qi Huan Company in Beijing, China**
- **One superconducting coupling coil (solenoid) magnet around the four RF cavities:**
  - Largest magnets in MICE:
    - Diameter ~ 1.5 m and 281-mm of coil length;
    - Stored energy ~ 13 MJ;
    - 250 A (design value), 166 turns/layer and 96 layers;
  - Three cryocoolers (baseline) to cool the magnet at 4.2 K;
  - Quench protection: passive with cold diodes and resistors;
  - Self-centering support system of the cold-mass;
  - Superconductors: 1 mm by 1.65 mm (~ 87 km/coil).



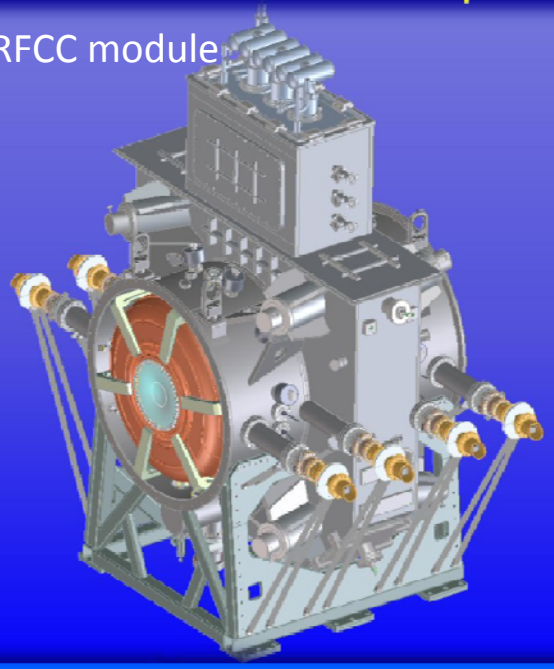
Summary of the RFCC Module

- **RF cavities:**
  - Status and plans (Allan DeMello's presentation)
- **SC CC magnets:**
  - 1st coil winding complete at Qi Huan Company in December 2010;
  - Fabrication of the cover plate for cold-mass and LHe pipe bending started in early June 2011 and complete now;
  - Cryostat design complete except
    - Quench protection and stabilization design of HTS and SC leads.
  - Welding of the cover plate at HIT
    - Fabrication of the welding fixture nearly complete;
    - Welding to be completed by July 15, 2011;
    - Cold mass to be shipped to the US between August and Sept. 2011
  - Plans for cold-mass and cryostat testing are being developed.

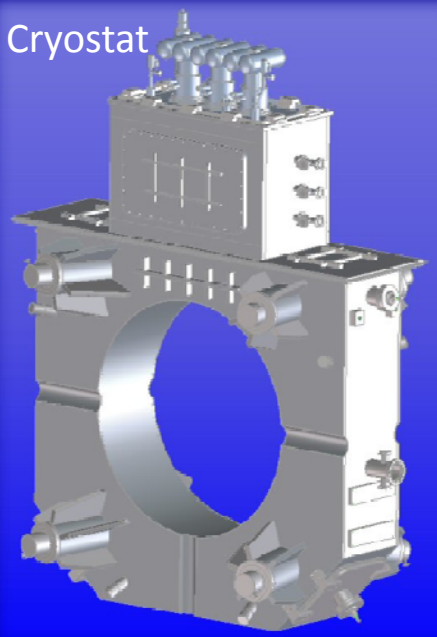
Cryostat Design of the CC Magnet

- Cryostat design complete, initial review process started, formal review to be held in Sept. 2011
  - Three cryocoolers (baseline);
  - Improved cooling circuit design and layout in consideration of fabrication and MLI wrapping and assembly;
  - 40-mm more spacing for MLI insulation and assembly.

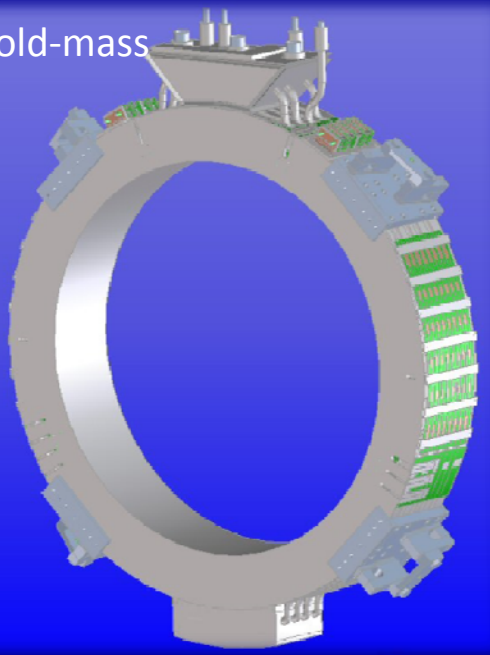
RFCC module



Cryostat



Cold-mass



Review of the 1st CC Coil Winding

1st coil winding complete in Dec. 2010

Coil winding at Qi Huan: last layer of SC wire (left) and finished Al banding (right)

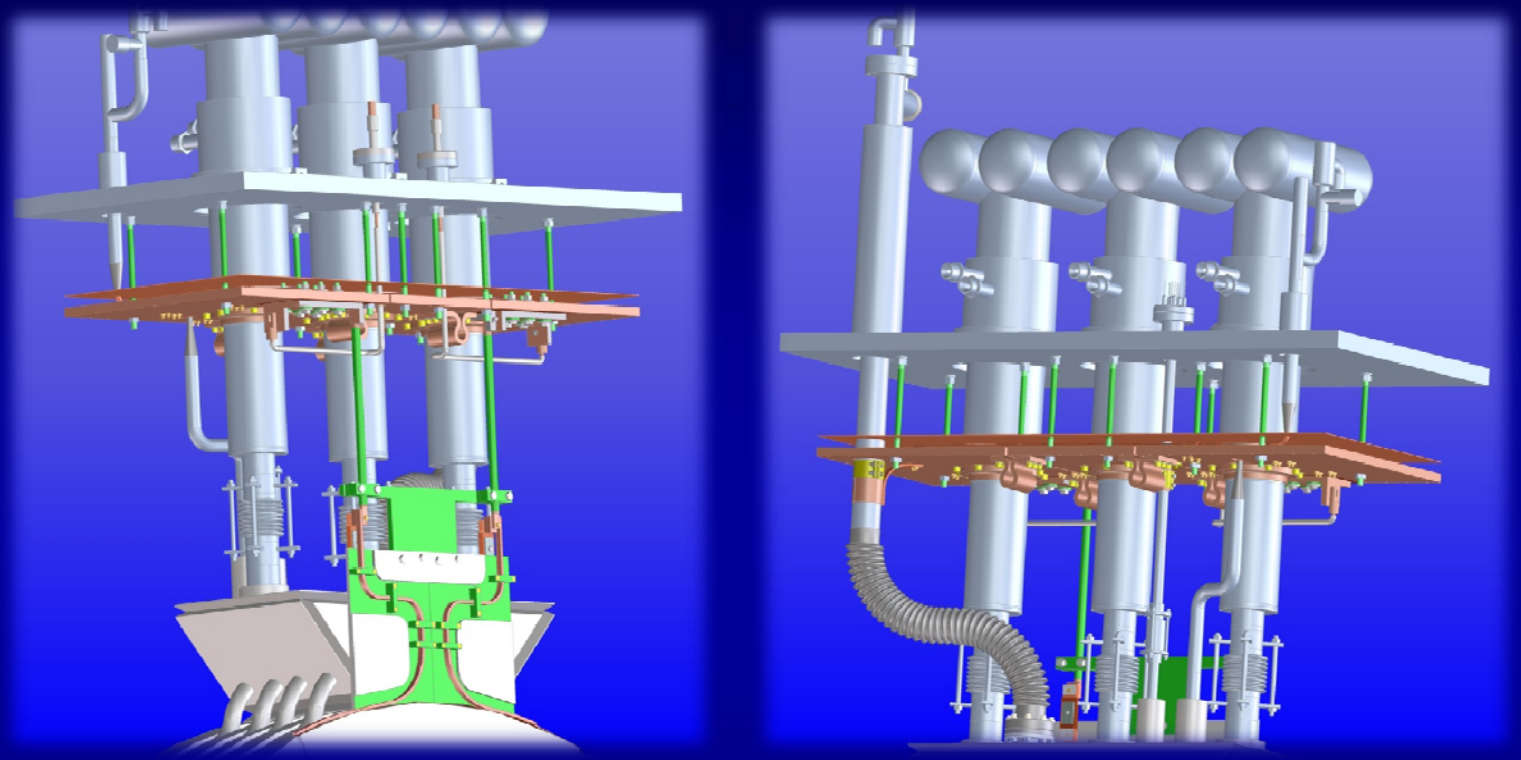
SC wire loop connecting to QP diodes.

SC wire leads from cold-mass.

Status of the CC Cryostat Design

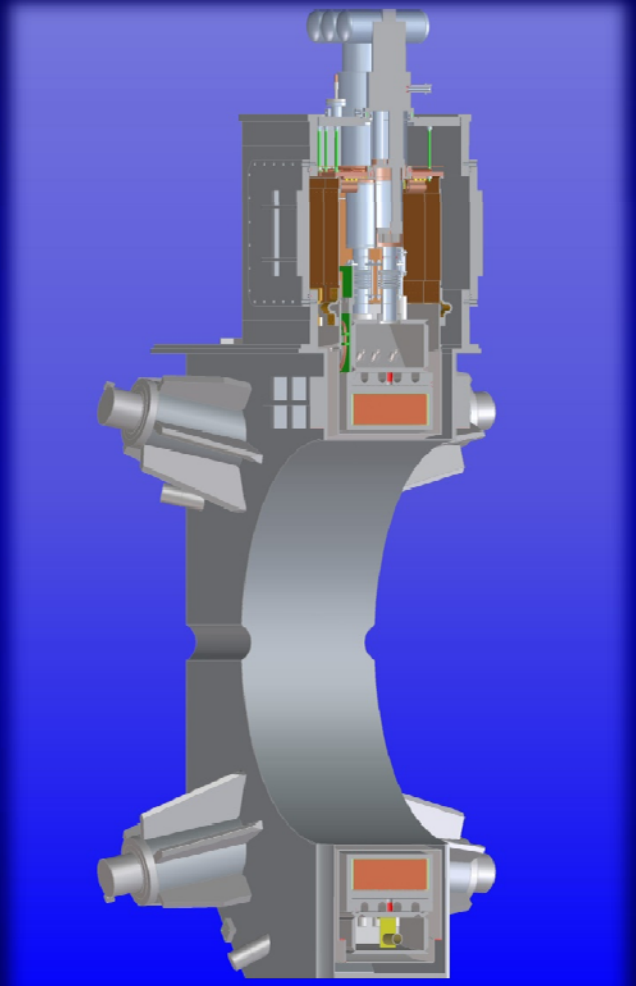
- Design complete by SINAP and sent to LBNL at end of March 2011;
- Procurement of Solid-Edge software at LBNL:
  - Translation and updating of the 3D model received from SINAP
    - Names of 2D files and links with the 3D model.
  - Implementation of updated design/changes nearly complete.
- 261 (2D) drawings sent out to RAL, Fermilab and RAL for preliminary reviewing;
- Further design improvement and updating implemented in May 2011 at LBNL:
  - Review fabrication and assembly procedures;
  - Improved cooling circuit design for easier assembly and MLI wrapping;
  - Identified and finalized diagnostic sensors (location and types);
  - Improved designs of HTS leads and SC leads for better thermal and mechanical stabilizations, further review and detailed designs to be complete by experts (MIT);
  - Quench protection to be re-evaluated at LBNL or by others (MIT);
  - Cold-mass and cryostat testing plans are being explored (critical for overall RFCC schedule).

The Cooling Circuit Design

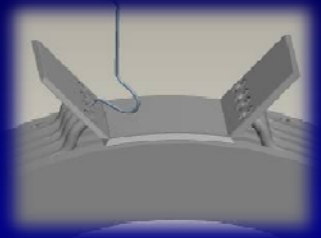


- Simplified design of the cooling circuit for easy assembly:
  - Moving all clamps and joints underneath the copper plate + flexible pipe;
  - Addition of a copper sheet for easier MLI wrapping;
  - Better thermal and mechanical stabilizations of HTS leads (conceptual).

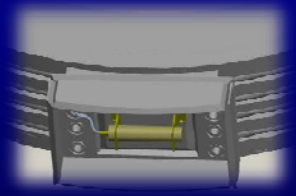
The Cryostat Design



- Kenol connector of LHe fill-line inside cooling pipe for easy assembly;
- The LHe fill-line goes to the bottom reservoir.

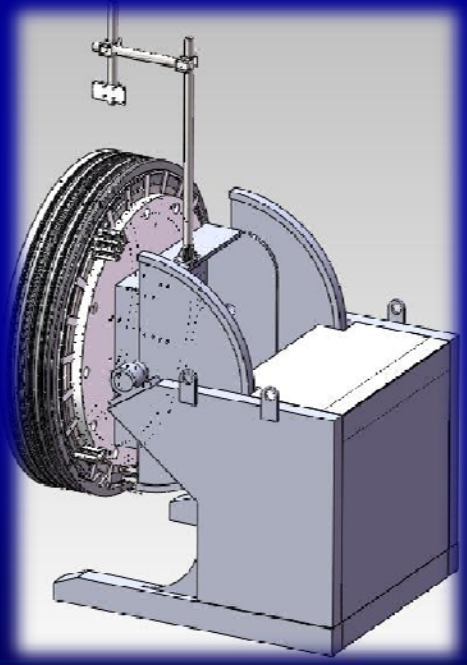


- New upper and bottom reservoir designs;
- Welding procedures allow for cold-mass test without the need of the certification of pressure vessel;
- A diffuser in bottom reservoir to prevent vapor trapping.



Cold Mass Cover Plate Welding at HIT

- **Two joints need to be welded at HIT**
  - Welding fixture design, fabrication and assembly complete;
  - Water cooling guidelines to reduce local temperature rise;
  - Multi-pass welding to control temperature rise (parameters developed from previous test samples);
  - Packing and shipping + export documents



Welding Setup at HIT

- Welding fixture and preparation nearly complete (final verification phase);
- Export and shipping documents signed by HIT officials;
- Leads and insulation protected and checked;
- Welding to be done by July 15th 2011.

CC Magnet Future Work

- Welding of the cold-mass cover plate by July 15, 2011;
- The cold-mass to be shipped to the US between August and Sept. of 2011;
  - Vacuum impregnation of epoxy at Fermilab or LBNL.
- **Cold-mass testing plan is being explored:**
  - Identified a cryostat at FSU;
  - Cold-mass testing in the US, ideal and potential place: Fermilab:
    - Initiated preliminary studies and assessment;
    - Technical analysis and test/management plans are being developed.
- Cryostat fabrication and assembly review summer (September) of 2011;
  - Fabrication of the cryostat parts should start after the review.
- Quench protection re-evaluation starts at LBNL soon, and need engineering design help on QP, HTS and SC leads stabilization (plan is being developed with MIT group;
- The ¼ testing coil testing preparation is in progress and will be tested at HIT this year (assembly contract awarded to a local company).

Plan and Schedule

- RFCC module schedule is mainly dominated by the schedule of CC magnets;
  - Cold mass testing is on critical path and affect overall RFCC schedule
- RF cavity work is currently on-hold to save resources for SS (highest priority) and CC magnets, but must start in FY12 in order to meet MICE step V schedule;
  - Fabrication, integration and RF test of the single RF vessel must start now
- Cold-mass testing of the first coils (1/4 testing coil and MuCool) is critical:
  - ¼ testing coil this year at HIT (progress limited by qualified manpower);
  - Cold-mass testing potentially at Fermilab, initial assessment suggests (Fermilab):
    - Six months to one year starting August 2011(?);
    - One year for cryostat assembly and testing .
- 2nd and 3rd coil winding starts after successful testing of the 1st coil or after QP analysis and design (?);
  - Procurement of more SC wires (FY11) for two or three (?) coils.
- Fabrication of cryostat parts can start October 2011 (after review);
- CC magnet testing with the real cryostat if the 1st coil testing is successful
  - Fabrication (in China) and assembly (US).

RFCC Tasks/Schedule

Difficult to have a realistic schedule without the cold mass testing plan & schedule

First CC magnet:

- Cold mass cover plate welding at HIT
  - 1 month
- Packing and shipping
  - Arrive Fermilab between August & Sept.
- Cold mass testing at Fermilab
  - 8 months
- Cold mass coil vacuum potting
  - 2 weeks
- SC wire procurement (by Sept. 2011)
  - Vendor identification;
  - Lead time: 4 months
- Cryostat design/fabrication
  - Design review: Aug. to Sept. 2011
  - Parts fabrication: 3-4 months (Qi Huan)
- Cryostat assembly & testing (Fermilab)
  - 12 months (estimate)
- Quench protection and leads designs
  - 2-3 months (MIT)

RF cavities:

- Cavity post-processing: mechanical surface cleaning, EP prep. and EP
  - 2-3 months at LBNL
- Power coupler: design updating, Fabrication and assembly
  - 6 moths at LBNL (funding)
- Cavity tuners (prototype+24 more for the 1st RFCC module
  - Started & may have to be done at LBNL
- Cavity support
  - 1 month
- Vacuum vessel fabrication
  - 4 months
- Be windows
  - Ready at LBNL
- RF ceramic windows
  - Ready, 4 at LBNL and 6 at Umass

Single cavity vessel: bidding started

RFCC Tasks/Schedule (cont'd)

2nd , 3rd and 4th (?) CC magnets:

- Coil winding/each at Qi Huan Company
  - 3-4 months
- Cold mass cover plate winding at HIT
  - 3 weeks
- Cryostat assembly (where? Fermilab or Qi Huan)
  - 2-3 months (best estimate)

RFCC module integration :

- Assembly
  - 6 months
- Where?
  - Fermilab or LBNL, definitely at RAL
- Packing and shipping
  - 1 month

Summary

- RF cavities, post processing and associated accessory components are under control at LBNL
  - RF work schedule dictated by the cc magnets and available funding and will start in FY12
- The CC magnet design has been improved significantly in the past year, we are more confident in the design
  - Experience and lessons learned from SS magnets;
  - Help from cryogenics and magnet experts (worldwide), and from MICE and MAP collaboration;
  - Progress on cryostat design and fabrication of the 1st cold-mass;
    - Tasks/schedule developed based on what we know so far.
  - The 1st cold-mass testing plan is being developed and critical;
- Realistic schedule of RFCC fabrication will/can be developed after testing of the 1st cold mass.